

IN THE SPECIFICATION:

Please amend the paragraph at page 1, beginning on line 17 as follows:

As a planar circuit type antenna using a dielectric substrate, for example, one of a microstrip structure comprised of a pattern of dipole type, patch type, log-periodic, or other antenna elements formed on a substrate and having the opposite side of the substrate made a grounded surface may be mentioned, but various other patterns may also be considered. The input/output of high frequency electrical signals from the feeder point of the antenna elements is usually performed by the method of arranging a feeder line (transmission line) perpendicular to or on the same plane as the element plane. In the case of arrangement on the same plane, the method may be mentioned of forming the transmission line integrally with the antenna element pattern and arranging wirings with the transmission line to the input/output terminals on the substrate. Further, in the case of arrangement perpendicular to the element plane, the method may be mentioned of arranging a feeder line passing through a through hole (via) so as to not ~~[[to]]~~ directly contact the grounded surface at the opposite side of the substrate.

Please amend the paragraph at page 2, beginning on line 1 as follows:

Further, when the impedance does not match with the feeder line or for balanced or unbalanced line transformation, there is the method of introducing a suitable matching circuit or balanced-to-unbalanced line transformer circuit, etc., between the feeder line and the antenna elements.

Please amend the paragraph at page 2, beginning on line 7 as follows:

As a planar circuit type antenna, one using an oxide superconductor is being studied. With the microstrip structure, one forming a dipole type, patch type, log-periodic type, or other superconductive film pattern at one side of the dielectric substrate and forming a grounded surface by that superconductor or ordinary conductive metal at the opposite side of the substrate may be mentioned. Further, in a planar circuit type antenna using an oxide superconductor, the technique of forming a superconductor filter and a feeder point of antenna on the same dielectric substrate and transferring high frequency electrical signals between the filter and feeder point of the antenna is being studied. As a passive circuit using such an oxide superconductor, the technique of forming a film of a copper oxide high-temperature superconductor on a substrate and forming a high frequency filter or other circuit by a planar circuit (microstrip line type circuit, coplanar type circuit, etc.), may be mentioned (M. Hein, *High-Temperature Superconductor Thin Films at Microwave Frequencies*, Springer, 1999; Alan M. Portis, *Electrodynamics of High-Temperature Superconductors*, World Scientific, 1992; Zhi-Yuan She, *High-Temperature Superconducting Microwave Circuits*, Artech House, 1994; etc.) If selecting a suitable copper oxide high-temperature superconductor film material with excellent crystallinity, it is possible to obtain a lower surface resistance compared with the usual good electrical conductors of copper, silver, gold, aluminum, etc., at a quasi-microwave band, microwave band, etc. Therefore, it is known that use of this copper oxide high-temperature superconductive film material is advantageous for a low energy loss (hereinafter abbreviated as a "high Q-value", reciprocal of dielectric loss tangent) and formation of a high Q-value circuit. To

form a superconductive planar type circuit, a pattern of a film of an oxide high-temperature superconductor is formed in accordance with need on one or both surfaces of the dielectric substrate such as magnesium oxide or lanthanum aluminate. The superconductive film epitaxially grown on the substrate perpendicularly with respect to the crystal lattice c-axis is advantageous for the formation of a high Q-value circuit. A YBCO superconductive film, etc., is used as the superconductive film.

Please amend the paragraph at page 3, beginning on line 14 as follows:

Further, while there are problems in practical use, by making the operating temperature one near the temperature of liquid helium (LHe) (4.2K), a circuit using a superconductive film theoretically can be made a superior one using a usual good electrical conductor even for the milliwave band or more (0.3THz or more).

Please amend the paragraph at page 3, beginning on line 20 as follows:

An antenna coupling module comprising a combination of a planar antenna and a planar circuit type superconductive high frequency circuit is, for example, disclosed in Japanese Unexamined Patent Publication (Kokai) No. 5-95213 (in particular, the claims and Figs. 1 and 5). This publication discloses an oxide superconductive antenna module comprised of a feeder system, matching circuit, and radiation element wherein the radiation element is formed by a meandering single line comprised of an oxide superconductive film and wherein the matching circuit is formed

by a meandering type 1/4 wavelength parallel coupling line made of an oxide superconductive film.

Please amend the paragraph at page 3, beginning on line 33 as follows:

In the antenna module disclosed in this publication, planar antennas arrayed on the same plane and a planar circuit type superconductive high frequency circuit are formed on the same plane. Therefore, the plane where this circuit is arranged is thought to end up becoming considerably larger. Further, when forming an array of a large number of antenna elements and trying to couple a superconductive high frequency circuit to the antenna elements, the ratio of the effective area of the ~~whole~~ entire antenna in the ~~whole~~ entire circuit on the plane becomes smaller compared with the case where the superconductive high frequency circuit is not in the same plane. Therefore, to obtain the same sensitivity, there is the problem that the area of the plane becomes relatively large.

Please amend the paragraph at page 4, beginning on line 23 as follows:

According to the present invention, there is provided an antenna coupling module comprised of a planar antenna and a substrate forming a planar superconductive high frequency circuit arranged in a perpendicular direction with respect to the element surface of the planar antenna and having the planar antenna and the superconductive high frequency circuit electromagnetically coupled. In this way, the planar antenna and the substrate forming the superconductive high frequency circuit are arranged perpendicularly and the antenna and high frequency circuit are electromagnetically coupled via a space. Therefore, it is possible to arrange antenna elements at a high density and possible to

produce a compact array antenna. By making this array antenna compact, it is also possible to make the system for cooling the conductors comprised of a superconductor compact as well, so it is possible to cut the cost of antenna production and the operating cost.

Please amend the paragraph at page 5, beginning on line 15 as follows:

~~An object of the~~ The present invention ~~is to realize~~ realizes an antenna coupling module electromagnetically coupling a planar antenna and a planar type oxide superconductive high frequency circuit which does not reduce the antenna effective area and which sharply reduces the signal loss due to connectors, etc., for coupling.

Please amend the paragraph at page 5, beginning on line 21 as follows:

~~Preferred~~ Exemplary embodiments of the present invention will be described in detail below while referring to the attached figures. The planar antenna used in the present invention is not particularly limited. It is possible to use all types of planar antennas which have been used in the past. For example, it is possible to use one comprised of a dielectric substrate on one side of which an antenna element comprised of a dipole type, patch type, log-periodic type, or other pattern is formed. Further, it is possible to use one of a microstrip structure with the opposite side of the substrate formed as a grounded surface by a conductor. Further, the antenna may also be an array antenna.

Please amend the paragraph at page 5, beginning on line 34 as follows:

In the present invention, the high frequency circuit is separated from the planar antenna and arranged in a perpendicular direction with respect to the planar antenna. ~~Due to~~ As a result of this, it is possible to reduce the area of the antenna plane by the amount that the high frequency circuit is not present on the plane comprising a planar antenna. Further, it is possible to reduce the area of the antenna plane by the amount not required for formation of a circuit for coupling the antenna and the high frequency circuit. Further, when arranging antenna elements in an array, since there is no high frequency circuit, it is possible to arrange the antenna array at a high density design wise.

Please amend the paragraph at page 7, beginning on line 10 as follows:

When the conductor forming the antenna element is an oxide high-temperature superconductive thin film, the dielectric substrate, in particular, a substrate for epitaxially growing a single crystal oxide high-temperature superconductor, is preferably for example a single crystal substrate made of magnesium oxide, lanthanum aluminate, strontium titanate, etc., but the invention is not limited to this.

Please amend the paragraph at page 7, beginning on line 29 as follows:

As the planar circuit type superconductive high frequency circuit, it is possible to use a circuit obtained by forming a superconductive film on a dielectric substrate. As the dielectric substrate, in general a single crystal substrate of magnesium oxide, lanthanum aluminate, strontium titanate, etc.,

is used.

Please amend the paragraph at page 9, beginning on line 17 as follows:

Further, by arranging the substrate forming the planar type superconductive high frequency circuit in a direction perpendicular to the element plane of the planar antenna, it is possible to eliminate the high frequency circuit from the antenna element plane and reduce the size of the antenna coupling module. Note that the "direction perpendicular to the element plane of the planar antenna" does not mean that the substrate forming the planar type superconductive high frequency circuit and the element plane of the planar antenna are completely perpendicular. While not necessary, they may also be inclined somewhat from the perpendicular direction. Cooling of the superconductive circuit requires much energy. Since it is possible to arrange the substrate forming the planar type superconductive high frequency circuit in a perpendicular direction with respect to the element plane of the planar antenna, the antenna coupling module as a whole becomes compact. ~~Due to~~ As a result of this, the system for cooling the superconductive circuit can also be made more compact. As a result, there is the effect that it is possible to improve the energy efficiency of the antenna coupling module as a whole.

Please amend the paragraph at page 10, beginning on line 2 as follows:

Further, the antenna coupling module of the present invention ~~is characterized by~~ electromagnetically ~~coupling~~ couples the element of the planar antenna and the superconductive high

frequency circuit. For coupling the element of the planar antenna and the superconductive high frequency circuit, there is also the method of coupling by connection by the transmission line of a conductive line, but by using an electromagnetic coupling system through space (or a dielectric body), it becomes possible to more completely utilize the advantage of the configuration of separating the planar superconductive high frequency circuit from the element of the planar antenna. That is, by forming the planar type superconductive high frequency circuit and planar antenna independently, it is possible to produce them separately. Therefore, the degree of freedom of production of a superconductive high frequency circuit is increased, production becomes easier, and improvement of performance and greater compactness become possible. To realize a high Q-value by a superconductive high frequency circuit, it is desirable to form it on a single crystal substrate by epitaxial growth. In the case of electromagnetic coupling, however, there is no need for conductor coupling for coupling the superconductive high frequency circuit and antenna element, so it is possible to independently easily produce only such a high Q-value superconductive high frequency circuit.

Please amend the paragraph at page 12, beginning on line 29 as follows:

Figs. 1A and 1B are schematic views of an antenna coupling module of an example of the present invention. In this example, the planar antenna is made a microstrip type of a patch of a quadrangular pattern, and a substrate forming a planar circuit type superconductive high frequency circuit is arranged in a perpendicular direction with respect to the element plane. As the coupling

circuit, a $1/4$ wavelength type feeder line is used. Fig. 1A is a schematic view of the cross-section when cutting the antenna coupling module in a direction parallel to the substrate having the superconductive high frequency circuit. In Fig. 1A, reference numeral 1101 is a patch antenna element. A cross-section of the quadrangular conductor pattern is shown. An effective $1/2$ wavelength of the transmitted/received wave is the rule of thumb for determining the pattern dimensions. An electromagnetic field simulator, etc., is used for the design. Reference numeral 1102 is an effective $1/4$ wavelength type feeder pattern, while reference numeral 1103 is a substrate material for forming the antenna, i.e., a dielectric substrate comprised of a polytetrafluoro-ethylene (PTFE)-glass composite. Reference numerals 1104, 1106, 1118, and 1120 are vias, while reference numerals 1105, 1107, 1117, and 1119 are grounding conductor layers. Reference numeral 1121 is a via connecting the feeder point of the antenna element 1101 and the feeder pattern 1102. As the conductor, copper plated with gold is used. In this case, for example, with transmission and reception near 10 GHz, the effective $1/2$ wavelength of the quadrangular pattern 1101 is about 1 cm. In Fig. 1A, the antenna element 1101 may be a length of the effective $1/2$ wavelength in a direction parallel to the paper surface and a length of less than the effective $1/2$ wavelength in the perpendicular direction. Reference numeral 1108 is a magnesium oxide single crystal substrate forming a high frequency circuit comprised of an oxide superconductive film. The superconductive film-forming face of the substrate surface is (100), while the substrate thickness is 0.5 mm. Reference numerals 1116 and 1109 are circuit patterns of an oxide superconductive film with a strong c-axis orientation. A Y-Ba-Cu-O system or Gd-Ba-Cu-O system having an average film thickness of 0.4 mm is used.

The circuit pattern 1116 is an effective $1/4$ wavelength type feeder. The circuit pattern 1116 electrically couples with the feeder pattern 1102 and is also used for impedance transformation. The circled part 1109 is a delay line. The reverse side of the substrate 1108 on the entire surface is formed with an oxide superconductive film similar to the film on the front surface of the substrate 1108. Reference numeral 1110 is a contact electrode for electrical connection with a 50 ohm characteristic impedance coaxial connector (SMA type) shown by 1113, 1112, and 1114 and is formed by vacuum deposition of silver or another metal. Reference numeral 1111 is a bonding material. Iridium solder or silver paste is used. When the thickness of the substrate 1108 is 0.5 mm, the widths of the lines 1116, 1109, and 1110 are made 0.5 mm for impedance matching at the time of operation with a co-axial connector. Reference numeral 1115 is a metal package comprised of Invar alloy, copper, or aluminum plated with silver to a thickness of 3 mm with an underlayer of nickel.

Please amend the paragraph at page 14, beginning on line 18 as follows:

Fig. 1B is a schematic view of the inside cross-section seen from a direction rotated 90 degrees about the perpendicular axis of Fig. 1A. Reference numeral 1201 is a element part of a patch antenna and shows the cross-section of the quadrangular conductor pattern. Reference numeral 1219 is an effective $1/4$ wavelength type feeder pattern, reference numeral 1222 is a substrate material for forming an antenna, and reference numerals 1205, 1206, 1207, 1223, 1224, and 1225 are vias including the vias shown in Fig. 1A. While the illustration is omitted for simplification, a dense

arrangement of vias is preferable for preventing useless operational instability. At 10 GHz, in the case of the material of this example, the intervals are made for example not more than 0.2 cm. Reference numerals 1208, 1209, 1220, and 1221 are grounding conductor layers, while reference numeral 1202 is a via for connecting the feeder point of the antenna element 1201 and the feeder pattern 1219. Reference numeral 1216 is a substrate for an oxide superconductor, reference numerals 1217 and 1218 are oxide superconductor films with strong c-axis orientations, reference numeral 1217 is a circuit pattern surface, and reference numeral 1218 is a grounded surface. Reference numeral 1215 is a contact electrode for electrical connection with the coaxial connector shown by 1212, 1211, and 1213. Reference numeral 1214 shows a binding material. Reference numeral 1210 is a metal package, while reference numeral 1203 is an indium sheet layer for electrically and mechanically connecting the superconductive high frequency circuit substrate to the metal package 1210. The metal package 1210 is thermally connected to the cooling end of a refrigeration machine and cools the circuits to 30 to 70K for circuit operation. Note that in Figs. 1A and 1B, for simplification of the illustration, the screws, jigs, the cooling system, etc., such as a cryostat are omitted.

Please amend the paragraph at page 15, beginning on line 17 as follows:

According to Example 1, the feeder line loss between the superconductive high frequency circuit and antenna can be ignored and the loss can be lowered. Therefore, compared with a combination of an ordinary conductive high frequency circuit and the same type of antenna, it is

possible to use a high Q-value circuit. This is advantageous for raising the sensitivity in the case of reception. When the superconductive high frequency circuit 1109 is a filter circuit comprised of a ~~multiple~~ plurality of resonators, it is possible to secure a lower path loss and frequency selectivity compared with a circuit of the same configuration using an ordinary conductive metal for the conductor patterns. For example, if arranging a plurality of patterns having pattern lines 1109 of the same line width and a length of an effective $1/2$ wavelength in series at suitable intervals, connecting the feeder line 1116 in series with a space, and arranging a feeder line similar to the feeder line 1116 in series with a space at the coaxial connector side, a bandpass filter can be constructed.